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AND ABSTRACT OF THE LITERATURE

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Health in Mercantile Establishments
I. The General Principles of Store Medical Service

Report of Two Cases of Di-Methyl-Sulphate Poisoning

The Case for Pithead Baths in Great Britain

Observations on the Toxicity of Tetranitromethylaniline, Tetranitroxylene, Tetranitraniline, Dinitrodichlorbenzene, and Metanitraniline

The Place of Industrial Medicine in Medical Science

Points in the Detection of Industrial Fatigue and Measures for Its Possible Complete Elimination

Determination of Aniline Vapors in the Air

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THE JOURNAL OF INDUSTRIAL HYGIENE

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HEALTH IN MERCANTILE ESTABLISHMENTS. I. THE GENERAL PRINCIPLES OF STORE MEDICAL SERVICE*

ARTHUR B. EMMONS, 2D, M.D.

Director, Harvard Mercantile Health Work, Boston, Mass.

ON December 1, 1919, under a co-operative arrangement between the Division of Industrial Hygiene of Harvard University and a group of twenty-five merchants, an investigation of health conditions and the problems of health conservation in stores was begun. The following report is the first of a series which will be issued covering this work.

The rise of industrial medicine represents one of the most recent and promising developments in preventive medical science, and since this rise has had its inception in the problems of industrial surgery and accident prevention it is natural that the store with its minimum requirements in these lines should have felt the impetus of the movement later than the factory, where such problems are in constant view. As a consequence of this situation, store medicine and hygiene, except in a very few establishments, has either failed to rise at all or has lagged so pointedly as to lack many of the prime elements of service which it is capable of rendering. A frank realization of this condition caused the following twenty-five firms to co-operate in exploring the entire field of mercantile health:

Chandler and Company	Boston
Chandler and Farquhar	Boston
Conrad and Company	Boston
Continental Clothing House	Boston
D. R. Emerson Company	Boston
Wm. Filene's Sons Company	Boston
The Gilchrist Company	Boston
The Halle Bros. Company	Cleveland, O.
L. P. Hollander and Company	Boston
Jos. Horne Company	Pittsburgh, Pa.
C. F. Hovey Company	Boston
Jordan Marsh Company	Boston
Lord and Taylor	New York City
Leopold Morse Company	Boston
F. P. O'Connor Company	Boston
L. S. Plaut Company	Newark, N. J.
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A. Shuman and Company	Boston
E. T. Slattery Company	Boston
Smith Patterson Company	Boston
R. H. Stearns Company	Boston
Wm. Taylor, Son and Co.	Cleveland, O.
R. H. White Company	Boston
T. D. Whitney Company	Boston
Woodward and Lothrop, Inc.	Washington, D. C.

THE NEED FOR STORE MEDICAL SERVICE

There is no type of organization which makes closer contact with the public and

* The second article in this series, *Health in Mercantile Establishments: II. Medical Records*, will appear in the December issue of the Journal of Industrial Hygiene. — *Ed.*

which depends more upon the goodwill which such contact should engender than does the store. Goods must be sold to the public in such a manner as to insure future dealing, and it is only through the possession of an intelligent, pleasing sales force, a well-systematized clerical staff, and a backing of thoroughly balanced executives that the delicate relations of efficient selling can be maintained. The part which good health plays in such a field of endeavor is unquestionably very large. The factory employee who is ill may fail in the production of goods, but the ailing salesman or saleswoman may not only fail to make sales but may also lose the goodwill of valued customers. It requires very little examination to realize that minor illness is a large and constant attendant upon store work. A sample monthly record from a store employing 700 individuals is as follows:

July, 1920	
Number of working days	22
Treatments by store nurse	240
Treatments by physician	70
Total	310
Per cent. of total employees	44.5
Referred to hospital	5
Referred to family physician	2
Referred to outside physician	3
Sent home because of illness	3
Rest room cases	24
Accidents involving compensation	3
Emergency floor calls	2
Heads of departments or executives treated	40
Customers treated	2
Need for visiting nurse service shown by:	
Absences reported as illness	32
Absences reported as family illness	8
Total	40

In another store employing 3,000 the attendance at the dispensary averaged about 200 daily, amounting in one month to over 4,300 or 1.2 visits per employee. Only fifteen of these were accidents of a moderately severe nature, the great bulk representing minor ills.

Manufacturers have made but few attempts to determine what fraction of their labor turnover may be ascribed to preventable illness and the stores with even less statistical knowledge in regard to illness have not approached such accounting. There are, of course, abundant data upon turnover *per se*, and apparently an average turnover of 100 per cent. is not excessive for a large store. If 3,000 individuals are employed, this means that 3,000 are hired annually in order to keep the working force intact, and, since each new employee means a cost of not less than $50, the loss so represented is enormous. That ill health must play a very large part in causing both turnover and absenteeism is certain, and one of the efforts of the group of stores involved in these studies should be to gain a correct estimate of the economic loss so sustained.

In order to attain such an end, records of illness must be kept by the physician in charge. It is sometimes held that the institution of record keeping by the doctor's office will result in a fear of the medical service supplied, the employees feeling that such records may be used against them by the firm. An objection such as this can readily be furthered by a tactless or pedantic store physician whose whole attitude enforces the idea that he is keeping this, that, or the other record for the sake of the records and not for the sake of the patients. While the physician's record should have a useful place in store accounting and in directing the activities of the medical department, it possesses equal value for the patient. Lack of individual records must hamper the store physician in treating a case, just as it must hamper the physician in private practice or the physician in the dispensary or upon the wards of a hospital. Industry has found it increasingly worth while to

record illness, and in organizations where the employees have partial control of the medical service record keeping is not relaxed. Nothing could be more deplorable than the institution of measures resulting in loss of confidence in the medical department by the employees, but such a loss of confidence will rarely occur and will never persist provided the physician in charge is a big enough man for his work. If disaster attends this phase of store medical service it has been caused by the selection of the wrong man or woman for the medical department and not by adherence to methods successful in industry, in private, and in hospital practice.

The Utility of Medical Service in the Stores

Without going into the details of the medical department, we may summarize its main points of usefulness as follows:

1. It should insure good sanitation, ventilation, and other conditions conducive to health and favoring efficient work with a minimum of fatigue. With these points in view, the physician should be sufficiently trained in the principles of preventive medicine, hygiene, and sanitation to be of real assistance in the planning and alteration of the store building and store equipment.

2. It should determine the physical fitness of employees, place wisely those who are slightly handicapped, and reject those whose employment would be a menace to themselves or to their fellow employees. To carry this duty properly there must be the closest co-operation with the employment department, coupled with a thorough understanding of the physical requirements of different branches of store work.

3. Recognizing that the chief opportunity for improvement of health lies in disease prevention, particular effort should be bestowed upon the treatment of minor complaints and the detection of incipient disease. Instruction in healthful habits of living should be given by means of personal advice, group health instruction, and articles in store papers.

4. The rare emergencies should be promptly met and the seriously ill directed how best to proceed so that no time may be lost in having proper treatment started. The store physician should place such cases in the hands of the patient's family physician, and he should also possess a list of reliable consultants to whom patients may be sent in the event of particular need.

5. The medical department should aid in determining proper sick benefits.

6. It should develop the records essential to intelligent treatment and, through statistical and graphic methods, should inform the firm what the medical department is accomplishing, at what cost, and with what gain.

In order to meet such duties efficiently, a physician of the highest calibre is essential and it is increasingly evident that the individual who will be most successful is the one who is giving his entire time to group medical work. This does not mean that the small store requires the full time of a physician, but it does mean that the physician employed should do no other work than industrial or store medicine, and that he should have been if possible specially trained for work in this field. His time may readily be divided between several stores but he should not divide it between store medicine and private practice, and, above all else, he should not be permitted to receive fees from store employees for service rendered.

The advantages accruing to the store from the development of such a type of service may in their turn be summarized:

1. The advantage of knowing how much time is lost through illness and accidents.

2. The advantage of reducing the absenteeism, the tardiness, and the inefficiency due to illness.

3. The advantage of constantly improving the healthfulness of conditions of work.

4. The advantage of knowing and causing the employees to know that they are at tasks equal to their physical powers.

5. The advantage of the assurance that when accidents or illnesses do occur, the best medical and nursing care is at once available and that the employee will return to work fit and at the earliest moment consistent with health.

6. The advantage of having good health habits taught in a systematic and effective way thoroughly suited to the needs of groups and individuals.

In order to attain a medical department from which such advantages as these must accrue, it is clear that much attention must be spent upon medical personnel, the executive position of the medical department in the store, the surroundings of the department, and the affiliations of the department with other branches of what used to be known as the "welfare" work of the store, but what is better designated the "service" division of the organization. Selby (*Studies of the Medical and Surgical Care of Industrial Workers*, U.S.P.H.S., Public Health Bulletin No. 99) in a recent report upon medical service in industry speaks of firms with as few as 400 employees using the whole time of a physician. Our examination of the store field leads us to believe that there are few establishments employing 1,000 individuals who will not, after starting medical work upon a sound basis, utilize the full time of one doctor. We have, however, felt that it is unwise to start upon such a basis, and recommend for a store of 1,000 the half time of a single physician who should be paid not less than $2500. The Division of Industrial Hygiene at the Harvard Medical School has made the subject of the salaries of industrial physicians a matter of particular inquiry and is conscious of the fact that there are at present not a few such men who are receiving no more than $2500 for full-time work. The type of man obtained for such a salary as this is almost invariably bad. He takes the work as a filler until he can find something better, or else he is driven to it through persistent failures in other types of medical practice. Neither situation promises benefit to the firm employing him. The store must expect to pay a reasonable initial salary such as we have designated, and must make it clear that if faced with real evidence of gain in efficiency through the existence of the medical department proper increases in salary will be forthcoming.

In selecting a store physician, the following professional and personal qualifications should be kept in mind. By training and temperament the store physician should be fitted to realize that his chief duty is to prevent illness. He should be sufficiently experienced in medical practice to discover the less evident signs of early disease. It is too often our experience to find that cases of tuberculosis or other slowly progressing disease has been discovered far too late for benefit, and after other employees have been exposed to serious danger from infection. He should be a co-operative, broad-minded man, capable of realizing that his success depends upon gaining and retaining the confidence of both the employees and the firm, and he should be able to realize that he will attain these ends not through agreeable talk and bluff, but through furnishing what is obviously the most honest and efficient sort of medical help to all who come to his consulting office.

The store management must realize that the medical department has capacity to render a uniquely useful service and that to accomplish this the physician in charge must be responsible to a member of the firm or to an official high in the work of the store. The man we are discussing possesses initiative and has been through a long

course of training in preparation for his work. It is fatal to place such an individual under the control of subordinate executives who lack the vision to appreciate the powers of development which the store physician's work possesses.

In addition to the physician, the store of 1,000 employees requires two registered nurses, and it is important that these two women have a course in public health work as part of their past experience. One of these nurses will be on duty in the store and the other will have the visiting work to do. Both should be taught that their value to the store rests not only upon their capacity to care for immediate illness, but rests also upon their power to instil quietly and constantly the principles of better health and preventive medicine upon which the entire structure of store medicine must rest. These women should each receive from $1500 to $1800. In addition to their salaries the medical department, if adequately housed, will require $1500 for supplies and miscellaneous expenses, making a total of $7000 for the yearly budget. Circumstances may make it possible to reduce this amount but it is probable that the store will find very early that it pays to increase. Such has been the experience of industry. We know of no case in which industrial medical service has been reduced after once being started, and a large series of cases are available illustrating gradual and wise enlargement after the department has demonstrated its utility.

Finally, a word or two may be written relative to the future work of the Harvard mercantile health group.

1. The medical and hygienic surveys of the stores will be continued.

2. Systematic dental care is a subject of especial study and recommendations for its installation will be forthcoming.

3. The best methods of health education, together with the material to be presented to the employees, need careful organization.

4. More accurate data in regard to causes of disability in store work will be gathered and the material made available.

5. Record keeping will be simplified if possible and standardized so that the health experience of different sections of the country can be made generally useful.

6. A method for furnishing medical service to small stores at reasonable cost and of satisfactory standard is under consideration.

7. Physicians and nurses are being especially trained for store medical work and listed so that stores may be supplied with reliable personnel in their medical departments.

REPORT OF TWO CASES OF DI-METHYL-SULPHATE POISONING *

FERDINAND D. MOHLAU, M.D.

Surgeon in Charge, National Aniline and Chemical Company, Buffalo

DI-METHYL-SULPHATE is an important substance in the newly organized dye industry. The following article is a report of di-methyl-sulphate poisoning in two workmen who were exposed to both the vapor of and the liquid di-methyl-sulphate.

Joseph Schmidt, the first patient, was a man 53 years old, weight 143 pounds, height 5 feet, 8 inches. When he entered the service of this country, the following defects were existent: very bad vision of the left eye (several scars on the cornea), large varicose veins, hernia on the right and left sides, general lymphatic enlargement, and defective teeth. Mr. Schmidt began working for the company April 6, 1920.

The second patient, John Carpenter, was aged 55, weight 185 pounds, height 5 feet, 8 inches. On entering the service of this company, he had the following defects: deficient vision of both eyes, varicocele, hernia of the right side, and defective teeth.

While opening some tanks of di-methyl-sulphate on May 26, 1920, these men, without using the necessary caution, were exposed to this chemical compound. They were not only exposed to the vapor but also to the liquid. With the exception of a slight irritation of their throats and eyes, they felt no effect at closing time and went home. The following symptoms appeared as the evening progressed. The irritation of the eyes became intensified, their throats became more irritated, and the inflammation of the bronchi became progressively worse. The cyanosis, which was just perceptible at first, became aggravated. During the night, Mr. Schmidt felt so ill that he called in a physician who unfortunately did not understand the cause of his disturbance. It was toward afternoon of the next day that we were informed of the man's absence and sickness. Upon visiting him we found the man delirious, with a severe congestion of his throat, symptoms of bronchitis, a severe inflammatory condition of the eyes, intense pain, photophobia and a severe migraine. With difficulty he was persuaded to go to a hospital. Subsequently Mr. Carpenter was visited and found in a similar condition. He also was sent to a hospital, where his condition became worse. He had an acute congestion of both lungs, an edematous condition of the throat and larynx and considerable cyanosis. Mr. Carpenter under proper treatment soon became rational while Mr. Schmidt passed into a comatose state. They both had a chemical pneumonia. Mr. Carpenter had a quick crisis and recovered. Mr. Schmidt, while recovering somewhat, relapsed several times with an aggravation of all symptoms. Eventually both made a recovery yet the condition of their larynges and eyes is still causing a great deal of trouble. Photophobia is still existent. The temperature of the patients at no time was very high, while their pulse rates were fairly rapid; in the case of Mr. Carpenter the pulse was of a peculiar quality. We found that all the mucous membrane of the two respiratory tracts had suffered a very decided corrosive change.

On an examination made July 8, 1920, Dr. F. Park Lewis states that Mr. Schmidt's color vision is practically destroyed, that all he retains is his macular color field.

* Received for publication July 14, 1920.

His field of vision at present is reduced to one-tenth of its normal range. His optic nerve shows pale outer edges but no degenerative changes are discernable.

The following is a report from Dr. Charles A. Bentz, our associate pathologist and bacteriologist, who in conjunction with Dr. R. L. Cameron has experimented with the gas and investigated its pathology on the body.

"About three months ago, Dr. R. L. Cameron, a physician connected with the Miniature Lamp Company, of East Ferry St., corner of Fillmore Ave., brought into my laboratory a rabbit which he had poisoned with di-methyl-sulphate. The Doctor stated that the substance was a liquid, and that he had saturated some cotton with it, and placed it under a bell jar with a rabbit. The animal died shortly afterward. The pathological findings were as follows: On autopsy examination, the blood in the vessels was fluid, and of a dark color. The organs showed intense congestion; the heart muscle was firm, and of good color; the right auricle was distended with blood, the other cavities were not dilated; the cortex of the kidneys was of an indistinct broad structure; the liver was large, pale in color, and mottled.

"Pieces of all the internal organs were preserved in fixing fluids and sectioned. The histological findings showed intense congestion of all the internal organs; the heart showed some parenchymatous degeneration, both in fresh scrapings, and stained sections. Beneath the endocardium the connective tissue showed peculiar mucoid degenerative areas; the kidneys showed acute parenchymatous degeneration; the liver showed intense parenchymatous and fatty degeneration, so marked that it was difficult to find even a few apparently undestroyed liver cells; the lungs showed intense edema.

"Bacteriological examination made of the important tissues and organs was negative, and showed the presence of no bacteria. Spectroscopic examination of the blood gave characteristic bands of methemoglobin. Smears of blood taken from the heart showed an apparently normal count; 8000 white cells (leucocytes), 5,000,000 red cells (erythrocytes). A differential count showed 50 per cent. polymorphonuclears, 48 per cent. lymphocytes, $1\frac{1}{2}$ per cent. eosinophiles, $\frac{1}{2}$ per cent. basophiles. The red cells showed no change in size or shape, nor were there any nucleated forms present. Coagulation of the blood was inhibited. Hemoglobin by Sahli estimation was slightly over 100 per cent.

"In conclusion, it is my opinion that the blood findings show alteration of the red cells by their combination with the poison; that the cell count is normal in number per cubic millimeter, but that there is a relative lymphocytosis present.

"The spectroscopic findings show that there was a combination of the poison with the red blood cells. The tissue changes show the effects of an acute degeneration, characteristic of a volatile poison carried by the blood stream to the various organs, producing the degeneration, the most marked change being in the liver in the form of parenchymatous and fatty degeneration. Just how much the edema of the lungs is due to irritation from the fumes of the di-methyl-sulphate, with the production of edema as a result of irritation, I am unable to state from this one instance. In order to establish that such findings in animals are consistent with di-methyl-sulphate, further experimentation should, I think, be carried out."

In the cases of Carpenter and Schmidt, clinical symptoms showed edema of the lungs; the urinary examinations in single and quantitative amounts showed an increase in the phosphates and sulphates, with a faint trace of albumin, an occasional hyaline cast and no sugar.

These findings, particularly the enormous increase of sulphates, point to liver involvement, and also to intestinal absorption. The clinical findings as well as the pathological changes, comparing the human cases and the experimentally poisoned animals, show consistent changes or lesions.

I am under obligations to Dr. Charles A. Bentz and Dr. Joseph A. Wintermantle for the assistance rendered in the making out of this report.

THE CASE FOR PITHEAD BATHS IN GREAT BRITAIN *

W. E. COSSONS

TO no class of workers is the problem of personal and domestic cleanliness more difficult than to the coal miner, and to the miner's wife. No industrial district is faced to the same extent as the mining area with that complication of its housing problem brought about — as Mr. D. Lleufer Thomas remarks in his introduction to the admirable little handbook on *Pithead and Factory Baths*,† recently published by the Welsh Housing and Development Association — "by the introduction into its streets and homes of an entirely avoidable industrial nuisance in the shape of the dust and dirt from coal which miners, for want of proper facilities at the pithead, carry with them on returning from their work."

The writer goes on to say that the publication of this book marks the launching of a new "offensive" against the twin enemies — Dirt and Disease. The war has brought about a new realisation of the economic value of cleanliness and the recent "Sankey" Commission has focussed a great deal of attention on the conditions under which this dangerous but vitally necessary industry is carried on. A lecture campaign, aided by the cinematograph, is to be carried on in Wales, the largest and most thickly populated mining area in Great Britain, with a view to educating the miner and convincing him of the many advantages of the pithead bath as against the home "tub," on the grounds of health, cleanliness, convenience, comfort, and decency. The nightly "tub" in front of the kitchen fire, used by all the male members of the family, including the sometimes numerous lodgers, was at one time a by-word in South Wales. Even now, according to the figures given by the medical officer of health for one of the largest mining districts (Rhondda), out of 26,822 working-class dwellings, 641 (only 2.14 per cent.) possess baths, and of these 550 are occupied by miners.

It is also pointed out that not only is there this lack of domestic washing accommodation, but also an all but complete lack of public baths of any sort.

> Where the need is greatest, there the provision is least adequate. While most of the larger seaport towns and such metallurgical centres as Birmingham or Sheffield, and also those parts of Lancashire and Yorkshire where the textile industries predominate are comparatively well provided with public baths . . . provision is scanty or non-existent in all the mining areas, despite the fact that such areas include some of the most densely populated parts of the country, such as the coal-fields of South Wales, Durham and Scotland.

The *Report on Public Baths and Washhouses in the United Kingdom*, issued by the Carnegie U. K. Trust (1918), states that the total provision in the whole (South Wales) coal-fields, omitting the seaport towns which are outside the mineral area, amounted in 1917 to only four swimming baths, together with a few privately owned "minor facilities." Since then some pithead baths have been added which are described in the book. With municipal baths at only two places and "minor facilities" of a proprietary kind at four or five, it is evident that by far the greater part of the area is left absolutely without any provision at all, and it is probable that an inquiry in other areas would disclose a similar state of affairs.

There is also an entire absence of public

* Received for publication July 20, 1920.

† *Pithead and Factory Baths* by E. L. Chappell and J. A. Lovat Fraser, with introduction by R. Smillie and F. Hodges (President and Secretary, Miners' Federation of Great Britain) and D. Lleufer Thomas (Chairman, Welsh Housing and Development Association). Welsh Housing and Development Association, Cardiff, 2/- net.

wash-houses in colliery districts. Hence the lot of the collier's womankind is made doubly hard — not only has she to provide for his daily bath at home, but she has also to wash his clothes. Well may a visitor stand aghast at the amount of mere cleaning the average woman of a Welsh colliery district has to get through, apart from other domestic duties, and wonder how she does it till he visits the cemetery and observes the ages recorded on the tombstones of the women! In another part of the introduction Messrs. Smillie and Hodges remark, "The miner's occupation will always be hazardous, but that is no reason why his home life should be everlastingly drab or that his wife or mother should be the life-long slave of the pit." It is pointed out, however, that pithead baths cannot be regarded as substitutes for domestic baths, neither, *per contra*, will a bathroom in every house adequately meet the need for the removal of industrial dirt.

There is, notwithstanding the obvious disadvantages of the present arrangements (or rather lack of arrangements), a considerable amount of apathy, if not prejudice, on the question. To quote the Carnegie report, there is found a dislike of "big establishments, and the women will not go long distances, but . . . they will avail themselves of small establishments . . . close at hand." But it is not only among the women, but also among the men that prejudice exists, notwithstanding the fact that the old miner's superstition as to the weakening effect of "washing the back" has nearly died out. Among other objections, there is the fear that having to wait their turn at the pithead bath will delay their getting home to their meals, their allotments, their sporting dogs or the inevitable "pictures."

These disabilities act and react on each other; inadequate housing, with its lack of privacy and convenience, inevitably results in a low standard of cleanliness and morality and, furthermore, of health, leading to excessive infantile mortality. There are hopes, however, for the future. The increasing interest of the younger generation of miners in athletics and physical culture, the mere economy of coal in heating the pithead bath, as against the supplying of coal at a nominal figure to each collier's home, the rising standard of comfort and self-respect, possibly also the newly-won voting power of women, will all have their effect.

One point, which may have been overlooked, to which Mr. Thomas draws attention, is that of the psychological effect on the collier class of facilities for cleanliness.

> . . . The social advantages . . . far transcend the merely utilitarian. . . . If in the streets and public conveyances, workmen, on returning from work in dirty clothes and with blackened faces, habitually meet other people with clean exteriors, consciousness of their own outward condition is bound to react injuriously on their minds and character. Their self-respect, especially if they form a minority of the population, is bound to be undermined and they are less likely to have a due regard for the decencies and courtesies of life. They are apt to believe that other people look down on them as if they belonged to a Helot class. . . . On the other hand, if they are in a majority, their wounded self-respect may occasionally lead them to over-assert themselves at the expense of other sections of the community. . . . I wish to suggest for serious consideration whether the "colour-bar" of the mining industry is not largely responsible for that spirit of sectionalism and of clannish trade-consciousness which seems to exist among the miners in a greater degree than among other workers. . . . This is something different from the ordinary class-consciousness of the working-class Socialist. . . .

The first portion of the book deals in detail with the points raised in the introduction to which we have referred. It draws attention to such points as the effect of the lack of accommodation for changing garments when the miner has, as is frequently the case, a long walk to work in bad weather, with perhaps a railway journey in a draughty carriage as well. He toils in a

high temperature, frequently in a wet working place, then turns out into the world again, to meet the greatest contrast of temperature. The figures quoted in *Dangerous Trades* (Oliver, 1902) show that, while 14.5 per cent. of the total deaths of miners are due to accident, no less than 40 per cent. are due to phthisis, pneumonia, and bronchitis. In addition, there is an enormous amount of illness due to rheumatism, sciatica and lumbago. As to home conditions, the authors give some startling figures which emphasize the points already alluded to. The following are striking:

Midlothian and Linlithgow (1912)

(Houses provided by mine owners for their employees.)

One room	11 per cent.
Two rooms	65 per cent.
Three or more	24 per cent.

(Bathrooms practically non-existent)

Stirling and Dumbarton (1908)

Number of miners	12,276
Average per house	1.65

An investigation in a number of typical colliery villages gave the following figures:

Number of miners' houses	2,266	
Average number of persons per house	5.59	
One-room houses	2.50	per cent.*
Two-room houses	84.2	per cent.*
Three-room houses	11.5	per cent.*
Four-room houses	1.8	per cent.*

The following are figures of the pre-bye-law era and date from the early nineteenth century or earlier.

Number of Houses	1643
One room	25.80 per cent.
Two rooms	71.51 per cent.
Three rooms	1.95 per cent.
Four rooms	0.67 per cent.
More than four	0.06 per cent.

Only forty-five of these had an inside water supply and there was none with a bath.

* These figures refer to houses built under the bye-laws and are the most modern in the counties. The four-roomed houses are not necessarily occupied by miners.

Dr. McVail, who is responsible for these figures, alluding to the deficiencies of the water supply, speaks of the large sums paid weekly by colliers' families for mineral waters for drinking purposes, and of a collier who even washed his face in soda water. Conditions in this particular respect, however, are now altered, though many Scottish villages still have a very deficient water supply and that very often of such a nature as to lead to outbreaks of enteric fever.

The figures for the Northumberland and Durham districts of England are equally striking, the percentages for overcrowding, as compared with 9.1 for England and Wales, ranging as high as 43.6. In the West Riding of Yorkshire, according to evidence given before the Coal Industry Commission of 1919, there were 2,793 families living in one-roomed houses and 31,908 in two rooms. Where such conditions exist it is not to be wondered at if uncleanliness is sometimes chosen as the lesser of two evils.

As far as the position affects women, the issue is frequently complicated by the fact that the men work in different shifts, arriving home at different hours. The miner's day is seven hours; the woman's, seventeen (or more). Medical men and others speak of the ill-effect on mothers and children of the strain of lifting heavy tubs, while a South Wales coroner remarks, "I have no hesitation in saying that hundreds of children have lost their lives during the last ten years through scalds at home. . . . Every winter I hold more inquests on miner's children who die from scalds or burns than I do on miners killed underground."

Summing up the advantages of the colliery bath, we may say that it would (1) improve the health, comfort, safety and moral purity of the miner and his family; (2) increase his efficiency, effect economies, and improve conditions of safety; (3) give

greater comfort to other members of the public who use the same conveyances as the miner; (4) increase the miner's self-respect and add to his status. With regard to the second group of advantages, we may note that the dislike of working in damp clothes is a prolific cause of absenteeism, and that when a man descends the pit in the garments he wears on the surface, he often inadvertently takes down matches which have secreted themselves in folds and creases of pockets and linings.

Chapter II deals with the history of the movement in favor of pithead baths in Great Britain. The metalliferous mines seem to have taken the lead in this respect; even in the thirties, some of the Cornish concerns had certain facilities, and today many of the owners have made provisions generously in excess of the minimum requirements of the law (Metalliferous Mines Regulation Act, 1872, Sec. 32, Rule 16). Further recommendations were made by a commission in 1914 but have not yet been put on the statute book. It is remarked, however, that such provision is not fully appreciated and there is no general demand by the workers for improved facilities.

In respect to coal mines, although some collieries had made experiments, it was not till 1911 that legislation was passed on the subject, and the first model scheme in this country was initiated in 1913 by Messrs. Fletcher, Burrows and Co., Ltd., of Atherton, Lancashire. Where previous experiments had been carried out, it was too often found that the facilities provided were not taken advantage of and in many cases the buildings were ultimately used for other purposes. The Coal Mines Commission of 1906–1909 recommended that the question of the provision of pithead accommodation should be determined by the attitude of the workers themselves. Basing their calculations on figures obtained in Germany, they said the cost of installation should work out at about 2*d*. per man employed, of which possibly the men should pay half. The commission did not, however, recommend that the use of such accommodation should be made compulsory, and, furthermore, insisted that action should be taken in the first place by the miners. Some of the miners' leaders, however, who sat on this commission were strongly of opinion that use of the pithead facilities should be made compulsory. When it was sought to give legislative sanction to these proposals — and the government included a section for making the provision compulsory — it was seen that there was strong objection from a considerable body of miners to being *compelled* to use the baths, the strongest objection coming from Durham, where conditions certainly do not compare favorably with other districts, bad as the other districts are. Though a resolution was carried in the face of this opposition and the Miners' Federation issued a strongly worded appeal in favor of retaining the compulsory clause, the general body of miners still remained unconverted, while the owners "of course objected to being compelled to undertake capital expenditure which did not produce additional revenue." The clause was therefore abandoned, and the Majority Report recommendations inserted, providing that where two-thirds of the employees desire accommodation and are prepared to pay half the cost of maintenance, the owners shall make provision for baths and clothes drying. After this act (1911) was passed, propaganda was carried out — very largely by the Women's Labour League — and in 1913 Mr. David Davies, M.P., Chairman of Directors of the Ocean Coal Co., Ltd., a very large concern, besides setting up a model installation at one of the largest of the firms' pits, sent a deputation of miners at his own expense to inspect various continental installations. The report of the Coal Industry Commission of 1919 gave further impetus to the movement.

The authors then go on to describe pithead washing and drying installations in various countries. Germany was the pioneer but, though most carefully arranged from a hygienic point of view, the lack of privacy characteristic of the German arrangements does not commend them to the British worker. Separate accommodation is provided, however, for boys of 18. Another objection to the German system is the waste of water as a whole section of sprays is controlled by one valve; thus, if only one man is bathing, the whole section is in action. The men are required to take home their dirty clothes every week-end and the whole place is thoroughly cleaned. The pre-war cost is estimated at $2\frac{1}{4}d.$ per man per week. In Belgium, bathing accommodation was provided — in some cases, of necessity, to retain the workmen — before it was made compulsory. The decree of 1913 made the provision of baths compulsory where the largest shift was not less than fifty men, and included minute details for the construction of the buildings, baths, clothes-storing and drying facilities. The shower-baths insisted on were enclosed in cabinets, ensuring a high degree of privacy. Use was not made compulsory on the men, and was gratuitous, but they had to provide their own soap and towels. Where less than fifty men formed the largest shift, wash basins and clothes rooms had to be provided. In France, accommodation varies greatly, but it was on a French model that the British Home Office based their regulations — the simple and inexpensive installation at Lens (No. 5) Colliery, Pas de Calais, of which a lengthy description, with diagrams, is given in the book. A great feature of this system is that each cubicle is divided into a "wet" and a "dry" compartment. The miner partially undresses in the common room, then enters the outer half of the cubicle where he divests himself of his other garments, and after he has had his bath (a shower controlled by the individual user) in the inner compartment, he returns to the "dry" half and puts on a portion of his clean clothes, which he has taken with him, completing his toilet in the common room.

Here one may point out the superiority of the suspended bag (with a lock, the key of which is in possession of the individual) for storing clothes kept at the mine, over the iron locker which is a feature of some systems. The drying of the clothes in lockers by steam pipes makes the building stuffy; the locker must be perforated, allowing dirt to get through. In some of the American installations two sets of lockers are provided, in different parts of the building, for working clothes and for clean clothes. In others, each locker is in two parts, the upper compartment for mine clothes, with steam pipes and fan for drying. In others, again, lockers are provided for street clothes only, a special drying rack, with coils of steam pipe below and a galvanised iron hood above, being used for the mine clothes. The law, as to provision and compulsory use, varies in the different states, and it is notable that some of the finest installations are to be found where no legal compulsion exists. The Bureau of Mines reported in 1914 that an average of 85 per cent. of the men employed in the mines investigated used the baths. In a large number of cases, a fee of from 50 cents to a dollar per month was paid by them. In New Zealand mines employing over fifty men, a request from thirty of them is sufficient to secure the obligatory provision of baths, but mine owners are not compelled to provide for more than one-third of the men employed, with the result that many of them prefer to go home rather than "wait in the queue."

After reviewing various British model systems, the authors proceed to discuss the demand for new legislation on the question. The underlying principles of Section 77 of the Coal Mines Act, 1911 are:

1. The onus of demanding accommodation is on the workmen, but, as the authors point out, the majority of men do not ask for what they do not see or understand, especially if a change of personal habits is involved. It may be noted here, as a writer in the *Daily News* (London) recently said, that a great many of the objections raised to the colliery bath come from the individual who benefits not least from it — the miner's wife. She holds a "proprietary" interest in her men folk and among other things fears they will catch cold if they turn out from a warm bath into a winter's night.

2. Employers are obliged to provide baths subject to certain conditions. Here the objection is that if the estimated cost of maintenance is more than 3*d*. per man per week, although an overwhelming majority of the miners may be in favor, the employer is not compelled to provide baths. As at present an installation cannot be put in for less than £1600 for 500 men, it will be seen that compulsion under this section is impossible.

3. The cost of maintenance is to be shared equally between employers and workmen. It is now contended by the Miners' Federation that the cost of removing industrial dirt should be a charge against the industry.

The authors then outline proposed new legislation starting *de novo*. They recommend that bathing facilities should be obligatory at all collieries (with certain special exceptions to be made after the strictest inquiry); that the cost of provision and maintenance should be charged entirely against the industry; that use by the men should be optional and that the management should be vested in a joint committee of workers and employers.

Space does not permit of further details, but, in concluding this brief summary of the book, it may be noted that a lengthy chapter is devoted to the answering of objections to the pithead bath system and one to the question of baths at works and factories other than mines. Specimen rules for management, detailed figures as to costs, are also given and the book is fully illustrated with photographs and diagrams.

OBSERVATIONS ON THE TOXICITY OF TETRANITROMETHYL-ANILINE (TETRYL), TETRANITROXYLENE (T.N.X.), TETRA-NITRANILINE (T.N.A.), DINITRODICHLORBENZENE (PARAZOL), AND METANITRANILINE*

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IN COLLABORATION WITH

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DURING the war several problems concerning the toxicity of various explosives or chemicals, used in munitions plants, were referred to the Otho S. A. Sprague Memorial Institute for investigation. The sudden cessation of munitions work terminated these investigations, most of them while incomplete. Some definite observations having been made, it has seemed desirable to make them available, and hence the following synopsis of some of our results is published. As they do not represent work carried to completion, the numerous protocols and much negative and inconclusive work are not presented. Numerous members of the Institute have collaborated in this work, as indicated in the text.

1. Toxicity of Tetranitromethylaniline (Tetryl), Tetranitroxylene (T.N.X.), and Tetranitraniline (T.N.A.)

Drs. W. D. Sansum and Julian H. Lewis administered these substances to dogs and rabbits in doses of grams per kilo of body weight and thereby ascertained their lethal dose, the clinical symptoms they produced, and, on autopsy, their pathological effects. The majority of the tests were made with subcutaneous injections of emulsions in olive oil. Attempts were made to give repeated small doses to dogs by stomach tube, but this method produced vomiting even when the substances were given in milk. Repeated small doses given to rabbits by stomach tube were less toxic than those given by the subcutaneous method. Daily inunctions with tetryl, the most toxic of the group, were made over long periods of time in dogs with no fatal results. A dermatitis soon developed in these cases, but no anemia or other blood changes resulted. In general, these substances were found to be relatively non-toxic, which may be partly explained by their relative insolubility.

Tetryl

The smallest fatal dose was 0.5 gm. per kilogram of recrystallized tetryl given to a dog subcutaneously in olive oil as five daily doses of 0.1 gm. per kilogram each. The dog lived fifteen days. Autopsy showed grossly a mild nephritis. Usually the organs showed no distinct gross pathological changes. The largest non-fatal dose was 2.5 gm. per kilo given subcutaneously as a single dose in olive oil. Five grams per kilo killed in less than eighteen hours. With these large doses much of the tetryl was unabsorbed. Rabbits given 1 gm. per kilogram of body weight by stomach tube in milk were killed after one to three doses. The same amounts given subcutaneously in olive oil were sometimes but not always fatal after six to ten doses.

Microscopically the tissues of rabbits and dogs after fatal doses of tetryl showed at

* This work was conducted under the auspices of the National Research Council. Received for publication June 23, 1920.

the site of injection a severe acute inflammation, with more or less edema and hemorrhage and sometimes waxy degeneration of muscles lying in the injected material. Without exception the kidneys showed toxic degenerations, so that in animals dying after a few days the epithelium was intensely swollen, with resulting albuminuria; usually there was much protein in the tubules and glomerular spaces, but little tendency to form casts. In one dog, dying within eighteen hours of the time of injection of 5 gm. of tetryl per kilo, the glomerular capillaries were distended with agglutination thrombi of fused red cells. In some cases there were areas of necrosis in the convoluted tubules. Fat granules were frequently found in the epithelium of the ascending loops of Henle in dogs, usually in moderate amounts, with little or no fat elsewhere. In rabbits the fatty changes were not found, although swelling and degeneration of the epithelium was marked.

The liver, in several dogs, showed marked changes, consisting of varying degrees of necrosis in the centers of the lobules and usually severe fatty degeneration of the liver cells, and also a noticeable deposition of fat in the bile duct epithelium. The rabbit livers showed almost no changes. Several of the animals showed more or less edema in the lungs and bronchi, in one case thrombi being observed in the pulmonary artery.

The spleens often showed blood pigment in moderate amounts, but without the congestion usually observed with hemolytic poisons. No noteworthy changes were observed in the other viscera.

Tetranitroxylene

The smallest fatal dose by subcutaneous injection was 1.2 gm. per kilo given to a dog as twelve daily doses of 0.1 gm. per kilo. The dog lived twelve days. The urine contained albumin and the kidneys showed a parenchymatous swelling. A rabbit receiving 1 gm. per kilo intraperitoneally died during the night, with much ascites. The largest non-fatal dose was 5 gm. per kilo given to a rabbit as a single dose subcutaneously in olive oil. No larger doses were given. The meta and para T.N.X. seemed to have the same toxicity. T.N.X. had no effect on the blood count. Goldfish were killed in fifteen minutes in a 1:100,000 solution of T.N.X., while they lived indefinitely in a 1:1,000,000 solution.

Microscopically the effects of T.N.X. were seen chiefly in the kidneys, in both dogs and rabbits the epithelium of the convoluted tubules showing more or less vacuolization, but no cast formation. A dog that received ten daily doses of 1 gm. each showed considerable calcification of necrotic tubular epithelium, similar to that seen in mercuric chloride poisoning. There was no excessive pigmentation of the spleen or other evidence of hemolysis. A rabbit that had four daily doses, each of 1 gm. per kilo subcutaneously, showed several areas of focal necrosis in the liver. A rabbit that received nine doses of 1 gm. per kilo by mouth in capsules showed only a fatty degeneration of the epithelium of the collecting tubules of the kidney and no other changes, indicating that little of the T.N.X. was absorbed. Two dogs, given each 5 gm. per kilogram in one dose subcutaneously and dying within eighteen hours, showed extreme fatty degeneration of the ascending limb of Henle's loops, but no other changes. In a few instances a slight fatty degeneration was observed in the center of the liver lobules.

Tetranitraniline

The smallest fatal dose was 2.5 gm. per kilogram given to a dog subcutaneously as a single dose in olive oil. The dog lived six days. The largest non-fatal dose was 5 gm. per kilo given to a dog as above. No larger doses were given. Rubbed on the skin as an

ointment, T.N.A. produced a dermatitis, and apparently some of it was absorbed, because of the effect produced on the urine. T.N.A. had no effect on the blood counts. Goldfish were able to survive in a 1:12,000 dilution of T.N.A. for at least two weeks.

Microscopically the effects of T.N.A. were as follows: At the point of injection of T.N.A. in oil there occurred a marked acute inflammatory reaction without suppuration. At times we have seen dark yellow masses of the material that have infiltrated ducts of the mammary gland and led to a striking epithelial proliferation, recalling the effects observed when oil solutions of Sudan III and Scarlet R are injected into epithelial tissues. Ordinarily the viscera showed no important gross or microscopic changes in dogs or rabbits given even large or repeated doses of T.N.A. The urine occasionally showed a little albumin, but not usually, and the renal changes were insignificant.

2. The Action of Parazol (Dinitrodichlorbenzene) on the Skin, and Substances Which Will Prevent It

The experiments were conducted by Dr. W. B. McClure and Dr. H. O. Lussky.

Parazol melts at 60°.. The pungent odor of the crude substance becomes more marked as the temperature is raised. At about 125°C. dense white fumes are produced and they become more dense as the temperature increases. These fumes are heavier than air and have a pungent penetrating odor. Crude parazol applied to the shaved skin of a rabbit produces hyperemia, edema, and at times necrosis, the degree varying with the duration of application. (The experiments extended up to two hours only.) On removing the parazol at the end of the application there is redness and edema extending well beyond the area of direct contact. This redness and edema usually reach their maximum of extent in area and degree at the end of six hours, and have usually subsided considerably at the end of twenty-four hours. The edema next disappears entirely, and finally after about four to six days there is a superficial desquamation, and then complete disappearance of the lesion. Occasionally superficial necrosis occurs. Linseed oil or water added to parazol causes no different reaction. The sublimate obtained by cooling the fumes arising on heating parazol to 80° are apparently slightly less active than parazol. In lanolin, parazol seems less active. Melted parazol has about the same toxicity as crude parazol, while purified parazol is distinctly less toxic than crude parazol. Mice lived in cages over crude parazol, apparently without harm. When exposed to fumes from heated parazol they gave evidence of marked skin irritation, but three-minute exposures were not fatal.

Crude parazol applied to the skin of man has the following course of action. Up to one hour application, no reaction occurred. Application for two hours produced hyperemia, finally a small vesicle. Application for three hours and fifteen minutes caused an itching at about three hours. A red slightly raised lesion, larger than the area of contact of parazol, was present on removal of the preparation; the edema increased somewhat during the next seven hours. After twenty-four hours the lesion was denuded superficially and tender to the touch. No extension of the area occurred. After forty-eight hours a flabby blister containing a clear fluid replaced the red lesion. After four days the vesicle collapsed and the edges were somewhat raised. After six days there was a red-brown scab. On the seventh day appeared what was probably a secondary dermatitis, manifested by secondary vesicles and hyperemia about the lesion, and marked itching. This gradually subsided and scaling resulted in final healing after about seven more days, only a small brown-red discoloration persisting.

Fumes from parazol heated to 80° and applied to rabbit's skin for five to fifteen minutes produced only a mild reaction (hyperemia and very superficial scaling with little or no edema). The fumes produced by heating to 150° and applied to rabbit's skin for five minutes produced a reaction definitely greater than fumes from the 80° heating. The white fumes produced by heating over a free flame and applied to the skin for one to eight minutes produced a much more marked reaction than the other applications.

Rabbit's shaved skin is protected against crude parazol by the following (given about in decreasing order of degree of protective power):

1. Sample C (1)

2. Sample A (2)
   Material Z (3)
   Material Z II (4)
   Material IV (5)
   Cloth III (6)
   } All having G.A.G. (12)

3. Oil silk (7)
   Water-proof horsehide (8)
   Oil cloth (9)
   Adhesive plaster (10)
   Split leather (11)
   Glove leather (ordinary dress glove leather)

4. Rubber was a poor protective

1. Sample C = Water-proof cloth. Two layers with 5 layers of G.A.G.
2. Sample A = Same as Sample C but with 2 layers of G.A.G.
3. Material Z = Muslin impregnated with G.A.G. and hardened with chrome salts.
4. Material Z II = Muslin impregnated with G.A.G. three times, then hardened with chrome salts.
5. Material IV = Muslin impregnated with G.A.G. three times.
6. Cloth III = Water-proof paper with 2 layers of G.A.G.
7. Oil silk = Bauer and Black.
8. Water-proof horsehide = Pfeister and Vogel Leather Co., Milwaukee.
9. Oil cloth = Cheap grade.
10. Adhesive plaster = Lewis Manufacturing Co., Walpole, Mass.
11. Split leather = Pfeister and Vogel Leather Co.
12. G.A.G. = (Helmholz and Lussky) glycerol, 50; acacia, 50; glue, 50; water, 200 parts.

3. Toxicity of Metanitraniline. Its Quantitative Determination in the Urine

These experiments were performed by Dr. Julian H. Lewis.

Metanitraniline is a yellow, light, fluffy, odorless powder. The sample used for experiments had a melting point of 111.5° (114° Beilstein). It is soluble in the organic solvents and slightly soluble in water. It forms a 3.5 per cent. solution when saturated in olive oil. The dry powder is rather volatile, as is shown by the fact that a filter paper covering a dish of the dry substance is colored yellow over night at room temperature. It is toxic for experimental animals, but not markedly so. Its toxicity for the various animals used stands in the following descending order: dog, cat, guinea pig, rabbit. A 6.3 kg. dog was killed in four hours by an intraperitoneal injection of 15 c.c. of a 3.5 per cent. solution in olive oil, or 0.07 gm. per kilo. The average sized rabbit (1.7–2 kg.) will stand an intraperitoneal injection of 15 c.c. of the 3.5 per cent. solution (0.2–0.25 gm. per kilo), without any marked toxic effects, but 20 c.c. usually kills and 30 c.c. always kills. One rabbit (1.9 kg.) received eleven daily injections of 10 c.c. of 3.5 per cent. M.N.A. subcutaneously without serious effects. A 2025 gm. cat was killed with 15 c.c. of the 3.5 per cent. solution given intraperitoneally. A 970 gm. guinea pig was killed with 7 c.c.

Death in all of the animals was acute and was manifested by dyspnea and convulsions. The autopsies of these animals showed the signs of asphyxia. The blood was of a dark color and did not coagulate readily. Methemoglobin was not found in the blood

on spectroscopic examination. Rabbits given repeated sublethal doses rapidly developed a profound emaciation and a blood examination of these animals showed a severe secondary anemia. For example, a rabbit was given subcutaneously 15 c.c. of 3.5 per cent. solution of M.N.A. in oil on December 1. Before the injection the red count was 6,560,000; white cells, 8,560, with 58.5 per cent. polymorphonuclears, 33.3 per cent. small mononuclears and 8.2 per cent. large lymphocytes. On December 3, the counts were: red cells, 3,792,000; white cells, 14,600, with polymorphonuclears 55.9 per cent., small mononuclears 27.1 per cent., large lymphocytes 12.3 per cent., unknown cells 4.7 per cent. The injection was repeated December 3, and on December 8, the red count was 1,548,000, with 6,233 white cells which included so many atypical forms that a differential count could not be made. On autopsy the changes of the bone marrow characteristic of anemia were found. The kidneys and spleen were usually swollen and very dark in color.

Microscopically the anatomical changes produced by M.N.A. were far more marked than those resulting from T.N.A., T.N.X. or tetryl. In animals living a few days there occurred a profound hemolysis and the changes found in the tissues seemed to depend on this hemolysis. The renal tubules were distended with masses of hemoglobin, either as small globules or fused into casts, which sometimes seemed to occlude nearly all the collecting tubules. The tubular epithelium was usually relatively unaffected, at most showing swelling or vacuolization, with little or no necrosis. In some the glomerules showed little or no change; in others the tufts were compressed by a protein exudate which did not seem to contain hemoglobin. No hemorrhage or inflammatory changes were observed. There was usually fatty degeneration of the epithelium of the straight tubules, especially in Henle's loops, in rabbits as well as in dogs.

In several cases there occurred more or less necrosis of the liver cells in the centers of the lobules, occasionally marked, and there was usually central fatty degeneration of varying degree. Fatty degeneration of the myocardium was sometimes found.

The spleen was distended with red corpuscles in acute cases, and contained much blood pigment in animals living longer. Often the blood in the vessels of preserved sections showed extensive hemolysis, presumably postmortem. Leucocytosis was often conspicuous.

The vessels of the lungs usually, and less often of the liver and other viscera, showed thrombi, sometimes of fibrin and sometimes apparently of agglutinated erythrocytes. This probably accounts for the varying degrees of pulmonary edema and distention of the right heart that were commonly observed, and for the sudden death with dyspnea and convulsions.

The urine of animals injected with toxic doses of metanitraniline showed marked and constant changes. It was of a dark reddish-brown color. It contained a trace of albumin and sometimes a few red cells; however, no hemoglobin was demonstrable with the guaiac test or spectroscopically. Methemoglobin was not present. This condition lasted about three days and the urine finally became normal. A second injection of metanitraniline always produced much less change than the first injection. In fatal cases there developed anuria, probably from occlusion of the tubules by hemoglobin casts.

Metanitraniline could always be demonstrated in the urine after injection, both in the free form and conjugated. To illustrate this, a sample of urine without previous treatment was extracted with ether. The ether was colored yellow. The extraction was continued until the ether was no longer colored. The urine was then mixed with an

equal volume of 40 per cent. sulphuric acid, allowed to stand one-half hour, and then neutralized with 20 per cent. sodium hydroxide. On repeating the extraction with ether it was again colored yellow. The extraction was continued until complete. The ether from both extractions was evaporated to dryness. Pure crystals of metanitraniline, determined by their melting point, separated on the sides of the vessels.

Dr. M. Th. Hanke devised a colorimetric method for estimating metanitraniline, which was based on the method of determining nitrates with paraphenylenediamine. Metanitraniline in a weak alcoholic solution is reduced to paraphenylenediamine with zinc dust and sulphuric acid. When mixed with sodium nitrate, paraphenylenediamine gives a brown color (Bismarck brown) which can be estimated colorimetrically. Table 1 gives the results of determinations of metanitraniline in the urine of animals after the injection of this substance. Plans to examine the urine of workers in metanitraniline factories to see if metanitraniline could be demonstrated by this method were frustrated by the cessation of war.

TABLE 1. — DETERMINATIONS OF METANITRANILINE IN THE URINE OF ANIMALS

Animal	Weight	Dose of Metanitraniline	Volume of Urine	Amount of Metanitraniline in Urine, Colorimetric Determination
Rabbit	1870 gm.	0.53 gm.	1st day, 100 c.c.	= 0.0675 gm.
			2d day, 110 c.c.	= 0.0053 gm.
			3d day, 17 c.c.	= 0.0 Total, 0.0728 gm.
Rabbit	2130 gm.	0.53 gm.	1st & 2d day, 79 c.c.	= 0.0775 gm.
			3d day, 70 c.c.	= 0.0 Total, 0.0775 gm.
Rabbit	1940 gm.	0.53 gm.	1st day, 85 c.c.	= 0.0612 gm.
			2d day, 94 c.c.	= 0.0213 gm.
			3d day, 109 c.c.	= 0.0 Total, 0.0825 gm.
Dog	10.5 kg.	1.05 gm.	Died in 3 hrs., 150 c.c.	= 0.00087 gm.
Dog	6.3 kg.	0.53 gm.	Died in 4 hrs., 1st hour's urine	= 0.00016 gm.

THE PLACE OF INDUSTRIAL MEDICINE IN MEDICAL SCIENCE*

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NO branch of medical science has been so much neglected in the medical schools of our country as industrial medicine and, in view of the reorganization not only of medical teaching but of industries generally, it is necessary that attention should be paid to this important subject. It is now realized that the health of the people is one of the principal assets of the nation and if the production of commodities and manufactures in industrial countries are to be increased, the health of the worker must be maintained at the highest possible level. This condition can only be brought about by a proper understanding of the conditions of labour in the various industries and of the dangers to which the workers are exposed as a result of their employment.

Each industry has its own problems and in the large cities where several industries may be centred it is essential for medical men who practice in such districts to have special knowledge of many industrial diseases. For instance, in North Staffordshire we have, in addition to the pottery industry, coal and iron mines, blast furnaces, steel works, chemical factories, by-product and coking plants as well as brick and tile works, so that a medical man in practice in this district should be conversant with such conditions as lead poisoning, silicosis of the lung, miners' nystagmus, beat hand, beat knee, beat elbow, poisoning by carbon monoxide and other gases, chrome ulceration, eczematous ulceration of the skin, etc., and he should be able to detect ankylostomiasis should this disease arise. In Lancashire, Yorkshire, the Tyne District, South Wales and many other great industrial centres where multiple industries are carried on, medical problems of an equally wide range are involved.

The Workmen's Compensation Act applies to nearly thirty different industrial diseases and their allied conditions, and in view of the numerous cases which arise year by year throughout the whole of the country, it is indicated that these diseases are widespread.

Let us consider for one moment the coal mining industry. In Great Britain alone more than a million men and boys are employed in this industry and each year during the last ten years there have been on the average 1300 fatal accidents resulting from employment in the mine. In addition to these fatal accidents, there are more than 160,000 non-fatal accidents occurring each year. As the result of the same employment and in spite of legislation, there has practically been no reduction in the number of fatal and non-fatal accidents in the mines of Great Britain during the last twenty years. I would point out that these 160,000 cases are non-fatal cases but do not include accidents of a trivial nature where no weekly compensation is paid; that, roughly speaking, during each year 55,000 miners are injured so seriously as to become incapacitated for work for between one and two months; and that at the end of each year there are 12,000 miners who have not recovered and who are totally incapacitated for work. Moreover, as I have said on previous occasions, it should be clearly understood that accidents in the case of a miner do not mean simply broken limbs or sprained backs but may be the cause of injuries which set up a sequela of symptoms. Diseases of a very serious nature may arise or may be intensified as a result of the original accident.

* An address given at the Industrial Hygiene Section of the International Public Health Congress held at Brussels on May 21, 1920. Received for publication June 21, 1920.

With regard to the disease known as miners' nystagmus, which is the commonest occupational disease known to medical science, Dr. Llewellyn has pointed out many times that this disease again is at a standstill. The cause is known, but nothing has been done effectively to prevent the onset of this protracted disease. The Home Office Statistics of Compensation for Great Britain during the year 1914 show that in that year 2,775 miners were totally incapacitated for work on account of this disease, and that 3,218 coal miners were suffering from it during that year, although their cases had been reported in previous years, so that the total number of miners receiving compensation during 1914 was approximately 6,000. When it is remembered that miners' nystagmus is a disease which takes from ten to twenty years to mature before complete incapacity for work is produced and that there are thousands of miners in this country who have received a lump sum settlement and who are employed in other ways, it is easily conceived that thousands of workers are affected by the condition. I have already said that practically nothing has been done to reduce the incidence of miners' nystagmus and that when a man has contracted the disease and is totally incapacitated for work there is practically no treatment for him beyond leaving the employment in which he has been engaged all his life.

After miners' nystagmus, the group of diseases (also concerning miners) known as beat hand, beat knee, beat elbow and inflammation of the synovial lining of the wrist joint and tendon sheaths constitutes the next largest group of industrial diseases which we know in this country; and I would point out that, of the total number of cases for which compensation is paid, the mining industry absorbs between 85 per cent. and 90 per cent. In 1914 there were 817 fresh cases of beat hand, 1609 new cases of beat knee and 346 cases of the other conditions, making a total of 2,772 cases, in addition to which there were a considerable number of cases reported in the previous year which had not been cured. Although so many cases of these conditions arise year by year there is practically no mention of them in the text books, and so much confusion exists as to the pathology of these conditions that even in the third schedule to the Workmen's Compensation Act in which they are included, while beat hand and beat knee are referred to as forms of subcutaneous cellulitis, beat elbow is described as bursitis of the elbow. As a matter of fact, beat hand, beat knee and beat elbow are identical from a pathological point of view.

If one views the medical aspect of the coal mining industry alone and recalls that there has been practically no improvement, at all events as regards the number of accidents occurring and the number of industrial diseases arising, there is almost virgin soil for the medical profession to work on, not only with a view of reducing the number of accidents but also of diminishing the number of cases of industrial disease; and, further, when one considers how diseases may be set up by accident or aggravated by an injury there are infinite possibilities for research in this direction.

It is, in my opinion, essential that medical men trained in the great medical schools of industrial countries such as England, Belgium, France and the United States should receive training with regard to the conditions under which men and women work in the various industrial districts. An intimate knowledge of industrial diseases is absolutely essential to the medical practitioner if he is to detect disease early and to prescribe the best treatment. Further, it is equally advisable on the ground that in the case of many industrial diseases it may be necessary for the affected workman to change his employment as soon as symptoms arise. This point spe-

cially applies to cases of miners' nystagmus and lead poisoning..

There is practically no provision for the teaching of industrial diseases in the medical schools of this country (Great Britain). It therefore follows that young medical men commence practice with no knowledge of these diseases and are obliged to obtain their experience at the expense of the patient. In this way it can easily be understood that cases of industrial diseases may not be diagnosed until it is too late and the patient may become a chronic invalid and his working days be at an end. In the interests of the state all medical referees under the Workmen's Compensation Act and all certifying factory surgeons should be familiar with the various phases of industrial conditions before they commence their duties.

From these remarks it is obvious that provision should be made for the teaching of industrial medicine in suitable centres so that experience can be gained prior to commencing practice. Further, in view of the importance of the subject and the widespread incidence of these diseases, I recommend that it be a compulsory subject for the examination for the Diploma of Public Health and that no medical practitioner be qualified for the position of medical referee under the Workmen's Compensation Act or certifying factory surgeon unless he has attended a recognized course of lectures or demonstrations on this subject.

POINTS IN THE DETECTION OF INDUSTRIAL FATIGUE AND MEASURES FOR ITS POSSIBLE COMPLETE ELIMINATION*

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THE major use of fatigue studies is their application to industry. It is because disease is associated so closely with fatigue that such studies have from the first had a closer relationship with medicine than with industry.

Fatigue in industry is a matter of extensive economic importance. In all countries, including the United States, the effect of the recent eight-hour day program has not by any means removed the fatigue hazard from industry, for the shorter workday applies to a relatively small proportion of the total number employed. It also applies to a considerable number, like railroad workers, whose working day is interspersed with many rest intervals. Even in the eight-hour day, vast numbers of people are employed for four straight hours at a spell under strain or in repetitive and very monotonous tasks. Nevertheless, there is no question but that the basic eight-hour day has laid the foundation for greater control of industrial fatigue.

Fatigue control in industry is at present a very haphazard affair depending largely upon the policies of employers who are checkmated by the responses of labor. Obviously this is quite unscientific and wasteful. The greatest advance in the control of industrial fatigue has come through the Frederick Winslow Taylor system of so-called "scientific management." In total, however, this applies to a relatively small proportion of industrial workers. The author of this system, a mechanical engineer, and its chief advocates — none of whom are physiologists — have formulated rules on quite empirical data derived from "practical" observations which conclude, for instance, that 43 per cent. of a laboring man's time may be under load and that 57 per cent. must be devoted to rest periods in order to gain maximum output.

The slowness of the findings of the physiological laboratory in becoming applied industrially is strange and appears to be due to two causes: first, that physiologists have chosen to limit themselves to pure science and have failed to suggest practical applications for industry, and, secondly, that the criteria or tests for determining fatigue in an individual (whole) man have not been perfected. As against this, the industrial demands have easily brought about the formulating of empirical standards, which, while open to much criticism as unscientific, still, from a practical viewpoint may succeed in doubling a man's daily production on apparently the same expenditure of energy.

There are now two schools of individuals engaged in study of the actual question of industrial fatigue — the first, the *mechanists*, or scientific managers and motion-study experts, as represented by Taylor, Gilbreth, Gantt, and Emerson, who have been busily at work in the field for the past twenty years and, claiming to have solved the question on purely mechanical lines, have fathered an economic movement of great importance; the second, a group of our *physiologists*, represented principally by Lee, Martin, Ryan, Kent, Hill, Florence and others who have been interested in the field of industrial fatigue for a much shorter time. It was largely due to the

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urgent solicitations of Dr. George M. Kober, Professor of Hygiene, Georgetown University, at the meeting of the American Public Health Association at Jacksonville, Florida, December, 1914, that the interest of American physiologists was first aroused, and there resulted a paper by Dr. Frederic S. Lee at the Rochester meeting of the Association in 1915, entitled *Is the Eight Hour Day Rational?* Later Lee announced *Industrial Physiology, A New Science* (1919), based on the conclusion which most physiologists come to who investigate the subject first hand, that industrial fatigue must be solved *in the factory* or workplace with all its attendant environment because the psycho-physiological tests of the laboratory are not of practical application to industrial workers, nor in factories.

The causes of fatigue in the human being are fairly well understood — enough so that standard rules may be established to circumvent the causes. Two sets of such rules are necessary — the one *intrinsic* and pertaining to the individual and standardizing the well-known factors of nutrition, blood and tissue oxygenation, circulation, elimination, reserve capacity (particularly as affected by disease and impairments), abuse of stimulants, the emotional state, degree of experience and skill, and amount and frequency of rest (or relaxation). Sleep is a phenomenon quite apart and distinct from fatigue. Practically the same amount (length) of it is required whether the individual is working or not, especially if the work is that to which he is accustomed. All of these intrinsic factors are affairs of heredity and growth, physical state of being, and personal hygiene. The status of all is discoverable through the health inquiry and physical examination. Most are governable through education and medical supervision. These intrinsic factors are by far the chief ones in the cause of fatigue; so much so that the writer believes it is only through considerable stress of extrinsic factors that the human body can be fatigued.

This brings us to a brief mention of the chief *extrinsic* factors in industrial fatigue. To itemize briefly, the chief ones of these are: laborious work, long hours, night work, overtime work, lack of periodical days of rest — so-called "one day's rest in seven" — piece work, spurt work, monotony, disharmonious rhythm, strains (such as constant standing, faulty postures and uncomfortable chairs), faulty illumination, faulty ventilation and many forms of distraction such as jarring or jiggling processes and noise. It will be seen that all of these extrinsic factors are fairly easily controllable. The possibility of control of both the intrinsic and extrinsic factors of industrial fatigue suggests the possibility of the total elimination of fatigue in the industrial worker so that he may eventually reach a state of equilibrium in which evidences of fatigue are not detectable. This may seem fanciful, but the writer believes it the ideal condition and one that is often attained, though unwittingly perhaps. In fact, upon a little reflection, most of us will admit the possibility of so arranging the work, nutrition, rest, and environment of the twenty-four hour day (omitting eight hours or so for sleep) that symptoms or signs of fatigue will not become apparent, subjectively or objectively. By developing along these ideal lines, why is it not possible at the same time to skill the human body to a degree of unusual productivity, meantime preventing evidences of any accumulative fatigue even for the space of a single twenty-four hour day?

Spaeth contends that the quantitative degree of fatigue cannot be measured as yet by any reliable method, although a number of reliable qualitative methods are extant. Inasmuch as the subjective sensation of fatigue is quite unreliable, being subservient to the emotional status, and

since we have no reliable method or methods for detecting the amount of fatigue present, the question arises, how do we know when fatigue is present or when it has been eliminated from industry ? If a broad view is taken of the possible existence of fatigue in a group of workers and this fatigue considered as purely a group or "mass" affair, a solution seems possible, as follows:

1. Adapt the workers to their jobs, not only by physical and past history examinations, which are necessarily important aspects of the problem, but by a careful selection and specification of standards for personal hygiene for the given job, including rest periods, best work methods, etc. This controls the personal equation.

2. Eliminate those environmental factors, so-called "industrial health hazards," which are known or believed to induce fatigue.

3. Make a practical application of all information gained by following up instances of health disturbances. These are to be sought for in resignations, absences, short-days and times off, mishaps and slips, decreased morale and *health complaints*. A checking up of health complaints requires detective work and an investigation of all instances of objective and subjective findings and sensations commonly known to be associated with fatigue (whether with other bodily states or not), such as headache, muscle pains, lethargy, anxiety, fatigue facies, postures and attitudes, dyspepsia, depression, decreased initiative, etc., etc.

4. Watch the output not so much from the point of view of quantity as of perfection, since fatigued workers may put out quantity but are less apt to satisfy the demands of quality.

Different amounts of fatigue in a group of workers are discernable as follows: *A day's fatigue* results in simple "tired looks," health complaints, stayed enthusiasm, and inaccuracies of execution. *A week's fatigue* results in obvious listlessness, minor indispositions, leaves of absence, loafing on the job, decreased morale, and incorrect attitudes, both physical and mental. *A month's or a year's fatigue* results in evident bodily afflictions (temporary or chronic, associated with deformity or impairment, both physical and mental), quite complete loss of morale and noticeable imperfections in work performed both as to quantity and quality. Obviously, the point of attack is the day's fatigue. Does the work group "quit fresh" as it is believed it should, or with fatigue evidences which even the next meal will not efface ?

To sum up, then, industrial fatigue seems capable of elimination by attention to known methods of grading the personnel, specifying and exacting personal hygiene, enforcing correct environmental hygiene, and by using as a check "mass" signs of the day's fatigue in a group of workers.

DETERMINATION OF ANILINE VAPORS IN THE AIR*

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TO be able to determine quantitatively the existence of a toxic substance in a definite volume of air is an important factor in bringing about improvement in industries where existing conditions are such that the substance in question is a menace to the health of the employees. The work considered in this article was undertaken with the purpose of finding a method whereby the percentage of aniline vapors existing in the air can be determined.

Previous Work

The toxicity of aniline is not a debatable question. Dr. Malden, in his report upon the examination of the blood of persons employed in aniline dye plants and suffering from aniline poisoning, confirms the results obtained from animal experimentation and proves the effect of aniline upon the blood of the worker (1). In Dr. Neisser's *Internationale Uebersicht über Gewerbehygiene* (2) the report is given of a medical investigator in England, showing the effect of aniline upon the worker. Dr. Thompson (3) in his book, *Occupational Diseases*, cites a number of cases of aniline poisoning reported by authorities working on aniline poisoning in Germany, France, and Austria. Drs. Hayhurst and Kober (4) recognize the highly toxic power of aniline, claiming the poison may be "absorbed through the skin by direct contact or from saturated clothing, by inhalation of vapors and impalpable dust, and also by way of the digestive tract." These men refer to the reports made by Dr. Apfelbach in 1913 and Dr. Birge in 1914, on cases of aniline poisoning in the United States.

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Of the work done by investigators interested in aniline poisoning in the United States, two interesting reports have been given, one by Drs. R. V. Luce and Alice Hamilton (5) in an article in the *Journal of the American Medical Association;* the other a bulletin by Dr. Hamilton (6) on industrial poisons used in the rubber industry.

Besides the reports of medical inspectors proving the fact that aniline is a highly toxic substance both in the form of a vapor and of a liquid, we have the experiments of Professor Rudolph Kobert with measured quantities of gases, showing that aniline is one of the most dangerous of toxic gases, very small quantities being poisonous. Kobert (7) has shown that 0.0004–0.0006 gm. per liter can be inhaled for one-half to one hour without severe symptoms, and that 0.0001–0.00025 gm. per liter give slight symptoms after several hours of continued exposure. Kobert, basing his statement on the fact that a worker taking 25 gm. of aniline died of aniline poisoning, says that the lethal dose of aniline for man is under 25 gm. (8).

The articles mentioned consider the toxic effect of aniline upon individuals. I have, however, been unsuccessful in finding any work dealing with a method for determining aniline quantitatively in and about the air of industries manufacturing aniline and aniline products.

Methods of Titrating for Aniline in Solution

Working on the assumption that aniline exists in the air as a vapor or attached to dust particles flying in the air, it was necessary to find some method of getting it into

solution so as to carry on titration. We know that aniline unites by direct addition to acids to form salts (9), as:

$$C_6H_5NH_2 + HCL = \underbrace{C_6H_5NH_2 \cdot HCL}_{\text{aniline hydrochloride}}$$

Having obtained an aniline salt in solution, the next problem was to devise a method for titrating such a solution in order to determine the amount of aniline present in the sample. Before a suitable method was obtained several different methods were employed and variations of these tried out. I shall here mention two methods which gave satisfactory results.

In determining the value and hence the accuracy of these methods, a definite weighed amount of freshly distilled aniline (1 gm.) was added to 100 c.c. of an approximately 10 per cent. solution of hydrochloric acid, and all titrations were made with this solution. In discussing my methods I shall speak of this as the standard sample. In all titrations a 50-c.c. burette graduated in 0.1 c.c. and giving 2 drops to a tenth was used.

Titrations

Method I. — This method is a modification of a method used by the research department of a plant working with aniline and aniline products. The materials used are:

1. Sodium nitrite solution — approximately 17.25 gm. to 1 liter of water, standardized every few days.

2. Starch iodide paper prepared according to the Frankford Arsenal formula.

A definite volume of the standard sample is cooled to 5°C. in an ice bath by adding cracked ice to the solution. It is titrated with sodium nitrite solution, not more than 1 c.c. being added to the nitrite at a time, and only one drop at a time toward the end. The first end point is taken when the solution gives an immediate blue color after fifteen seconds stirring when spotted upon the starch iodide paper. Next, the temperature of the solution is brought up to 10°C. At this temperature the reaction on the starch iodide paper should be negative. Then sodium nitrite is added, a drop at a time, with thirty seconds stirring between each drop. An immediate blue color, which lasts five minutes after the last previous addition of nitrite, is the final end point.

Calculation:

$$\frac{\text{c.c. } NaNO_2 \times \text{aniline equivalent to 1 c.c. } NaNO_2}{\text{no. c.c. of sample}} =$$

aniline present in 1 c.c. of sample.

This method is an accurate one since in all ten tests made with it I was able to account for within 0.3 mg. of the exact amount of aniline placed in the sample.

Method II. — This method was furnished to me by the company through whose courtesy the practical application of my methods was made possible. The titration as furnished by them was as follows:

Analysis of Aniline, Aniline Salt, and Standardization of Sodium Nitrite Solution

Reaction. — $(C_6H_5\,NH_2 \cdot HCl) + NaNO_2 + HCl = (C_6H_5N - NCl) + NaCl + 2\,H_2O$

Solution. — (1) Sodium nitrite solution approximately 10 per cent.

(2) Starch potassium iodide solution from bottle which must be used only three days after opening.

(3) Aniline for standardization is prepared by distilling commercial aniline through a clean condenser and collecting the middle portion over a range of 0.2°C. This special aniline is to be kept in a glass stoppered bottle and labeled "Aniline for Standardization."

Standardization. — Weigh out accurately about 10 gm. of aniline for standardization in a glass stoppered weighing bottle. Pour into a 500-c.c. beaker containing ice which has been washed. Wash weighing bottle and stopper with 50 c.c. of 10 per cent. hydrochloric acid. Stir with a paper scale thermometer (C. 100°), protecting the mercury bulb against breakage by slipping a three-fourths inch piece of black connection tubing over it. Add 25 c.c. concentrated hydrochloric acid. See that all aniline

hydrochloride crystals that are formed on addition of concentrated HCl are dissolved. Add distilled water sufficient to make total volume about 250 c.c.

First End Point. — When the temperature is between 5° and 8°C. add the sodium nitrite solution, drop by drop, from a burette at a rate not exceeding 2 c.c. per minute, constantly stirring. Continue adding the sodium nitrite solution until a drop of the solution taken out on the end of the thermometer and dropped on a drop of starch iodide solution on a spot plate gives an immediate blue color. If the temperature is between 7° and 8°C., this is the first end point. If the temperature is below 7°C., it must be raised to between 7° and 8°C. for the first end point.

Final End Point. — Set the beaker in a pan of water at 13° and stir solution until temperature is just 12°. (Caution: — Do not warm over flame or steam bath as the diazo benzene chloride formed is decomposed by heat.) The solution should now give no blue test; if it does the end point has been passed and a new sample will have to be started.

If no blue test is obtained, keep temperature between 12° and 13° and resume titration, adding 4 drops of nitrite solution, testing after exactly fifteen seconds stirring. (Use watch.) When an immediate blue has been obtained at this rate, the titration rate is changed to 2 drops of nitrite solution, testing after thirty seconds stirring, when a blue test constitutes the end point. The solution after being stirred an additional two minutes must still give an immediate blue test and final temperature must be 13°.

Calculation. — Example: Divide the cubic centimeters of sodium nitrite used into the weight of the aniline and the result will be the weight of the aniline to 1 c.c. sodium nitrite solution.

17.8297
6.9427

10.8870 gm. aniline
Used 86.9 c.c. $NaNO_2$ solution

$$\frac{10.8870}{86.9} = \begin{cases} 0.12528 \text{ gm. aniline per} \\ \text{c.c. } NaNO_2 \text{ solution} \end{cases}$$

Analysis of Aniline, Aniline Water, and Aniline Salt. — To analyze aniline, aniline water and aniline salt, proceed exactly as in the standardization. Be careful to wash all of the sample from the weighing bottle, using a wash bottle containing a 10 per cent. solution of hydrochloric acid.

Calculation:

$$\frac{\text{aniline equivalent to 1 c.c. } NaNO_2 \times \text{no. c.c. } NaNO_2}{\text{amount of sample in c.c.}} = \text{aniline present in 1 c.c. of sample.}$$

Precautions. — When titrating for the first end point or at any one of the specified rates, an immediate blue must be obtained before going to the next rate. Emphasis is placed upon an immediate blue because all tests turn blue slowly on using 1 drop of nitrite solution in 400 c.c. of distilled water containing 25 c.c. of concentrated hydrochloric acid, on stirring thirty seconds. A good starch solution will give an immediate blue free from any reddish tinge.

This method was employed by me with the following modifications:

1. A 1 per cent. solution of sodium nitrite was used instead of a 10 per cent. solution.

2. Starch potassium iodide paper the same as used in method I was used instead of potassium iodide solution.

3. In standardizing, 1 gm. of aniline was used instead of 10 gm.

4. In adding sodium nitrite solution, never more than 0.1 c.c. was added at a time and the solution was always stirred fifteen seconds between each addition. These changes were made because I was dealing with a very weak solution of aniline salt. The results of the titrations proved that this method could be used with the same degree of accuracy as method I.

Summarizing the results of the above two methods of titrating, I found both sufficiently accurate to be employed in carrying out future phases of this problem. The following points and precautions are to be remembered:

1. The sodium nitrite solution should be made up fresh every few days and should be restandardized each day, because of the danger of deterioration due to bacterial action.

2. At least two check titrations should be made on each sample.

3. The temperature should be held at the exact degree stated in the methods for a change in temperature of 1°C. means a change of 0.1 c.c.–0.3 c.c. in the final end point.

Tests of Apparatus

Having determined that the above methods were sufficiently accurate to detect small amounts of aniline in solution, the next phase of my problem was to devise a method of collecting aniline vapors from the air. Three different kinds of apparatus presented themselves as feasible for use: namely, the Palmer dust collecting apparatus, the carboy, and the Pettenkoffer absorption tube.

Since aniline vaporizes a little above room temperature and boils at 363°F., a flask containing freshly distilled aniline was weighed, and by means of a double-bore stopper was attached directly to a condenser through one bore, and by means of a bent glass tube in the other bore was directly connected with the apparatus to be employed in collecting the vapor. The purpose of the condenser was to recondense any escaping aniline if the fumes became too heavy to pass over to the apparatus. When the apparatus was attached, a slow gas flame was put under the flask containing aniline, the weight of which had been determined previously. Just sufficient heat was applied to let the aniline fume slowly. When all the fumes had passed into the apparatus, the flask of aniline was reweighed, the difference in weight being the amount taken up by the apparatus. Each of the three methods was tried in turn, their efficiency being determined by using titration methods I and II, and determining how nearly the loss in aniline weight checked up with the amount accounted for in the samples collected. If the results checked up within 0.001–0.003 gm., they were considered to be accurate. Tests were made by passing known volumes of the fumes of aniline through a 10 per cent. solution of hydrochloric acid in carboys, Pettenkoffer tubes (10), and Palmer dust collecting apparatus (11). The results of these tests showed that:

A. The carboy could be used, for all the fumes of aniline introduced into the acid were accounted for to 0.001 gm. In using this method for determining the amount of aniline present in the air, however, it was necessary to use a carboy having a volume of at least 15,000–20,000 c.c., since the amount of aniline in a smaller volume than 20,000 c.c. of air would probably be too small to be determined with any degree of accuracy.

B. The Pettenkoffer tube method was a feasible method if two tubes were joined and the fumes allowed to pass from one to the other. Also by introducing a plug of glass wool 1 inch in length at the proximal end, greater surface was obtained. The value of this apparatus lies in the fact that the long tubes gain more thorough absorption.

C. The Palmer dust collecting apparatus was tried out but proved inefficient because the air passed through the column of acid too rapidly and the column was too short to entrain all the aniline.

In summing up my preliminary work, I found that titration methods I and II would show the presence of 0.001 gm. or more of aniline and that both the carboy and Pettenkoffer tube methods were possible means of determining the amount of aniline existing free in the air. The Palmer dust collecting apparatus is of no value in determining the amount of aniline existing free in the air, but in any process using aniline, accompanied by a great amount of dust, this apparatus can be employed by using a medium for entraining the dust particles and one in which the aniline is soluble. A consideration of this method as a means for determining aniline in industrial dust is to be given in another article.

Practical Application of the Methods Tested

In trying out the methods described, a series of tests was run at a plant where

aniline and aniline products were manufactured. The plant where this work was conducted was a modern one, the company constantly endeavoring to improve conditions hazardous to health. Before beginning the tests, therefore, I felt that aniline, if present, would be found in very small quantities, in which case the methods, if practical, would be all the more valuable. Aniline at the plant in question existed in two forms: namely, (1) as free aniline vapor in the air, and (2) as aniline attached to the flying dust where the process was a dusty one. The aniline house and the indigo house were suggested by the company as possible places for detecting aniline in these forms.

Aniline. — In the manufacture of aniline there are two phases where it is possible to find aniline escaping into the air: (1) When the reducers are dropped, the aniline passes from the reducer into the still as a very hot liquid. Formerly this fuming aniline was dumped into an open pan placed over the still hopper, hence letting great amounts escape into the air, and frequently it was seen to slop over the side. At present the amount of aniline escaping is reduced by the installation of air suction pipes from the hoppers, which draw the vapor downward. The aniline which does escape exists in the air as vapor. To drop a reducer takes about twenty minutes, all conditions being satisfactory. (2) After distillation the tank containing the residue (iron oxide) at the base of the still is opened for cleaning. When this takes place the iron oxide dust passes into the air carrying with it considerable attached aniline. This process requires about ten minutes. At intervals the worker, standing in front of the tank, helps along the process with a long pole.

Indigo. — The one phase of the process of making indigo where aniline can escape into the air in quantity is when the driers are opened, tilted and the phenylglycine is shoveled by hand into barrels. Clouds of phenylglycine containing more or less free aniline at this time escape into the air. The worker here is supplied with a respirator and gloves as means of protection, but respirators up to the present time are not satisfactory and the workers do not wear them. At this phase of the process the aniline escapes into the air, either as a vapor from the fuming lumps of phenylglycine or attached to the particles of dust. It should be noted here that the company at the plant of which the experiments were made is at present dissatisfied with the present vacuum driers, which are German made, and are installing vacuum drum driers, which will do away with a great deal of the dustiness. This change is being made because of the fact that so many workers are reported ill from time to time in this department and the company, feeling this is due either to the toxicity of the phenylglycine or to the aniline, are introducing the new American-made machinery.

Tests for Aniline Vapors

At the plant studied tests were made for free aniline vapors in the air using the Pettenkoffer and carboy methods. These tests were carried out by setting up the apparatus at two different levels, namely, floor level and the level of the worker's mouth. All tests were made at the same distance from the process as that at which the worker conducting the process stood. The tests were made in the aniline house while the reducers were being dropped and in the indigo house while the vacuum driers were being emptied.

In carrying out the tests two methods were employed in collecting the samples. These methods were as follows:

1. *Carboy Method.* — Carboys ranging in volume from 15 to 20 liters were filled with water (aniline-free), and were emptied at the source of collection of the sample, being thus filled with air to be tested for aniline. The amount of water expelled was

noted for this measured the amount of air introduced. Immediately 200 c.c. of an approximately 10 per cent. solution of hydrochloric acid were poured into the carboy, the carboy stoppered and agitated freely at intervals for one-half hour. It was then allowed to stand for one-half hour to permit thorough absorption of the aniline

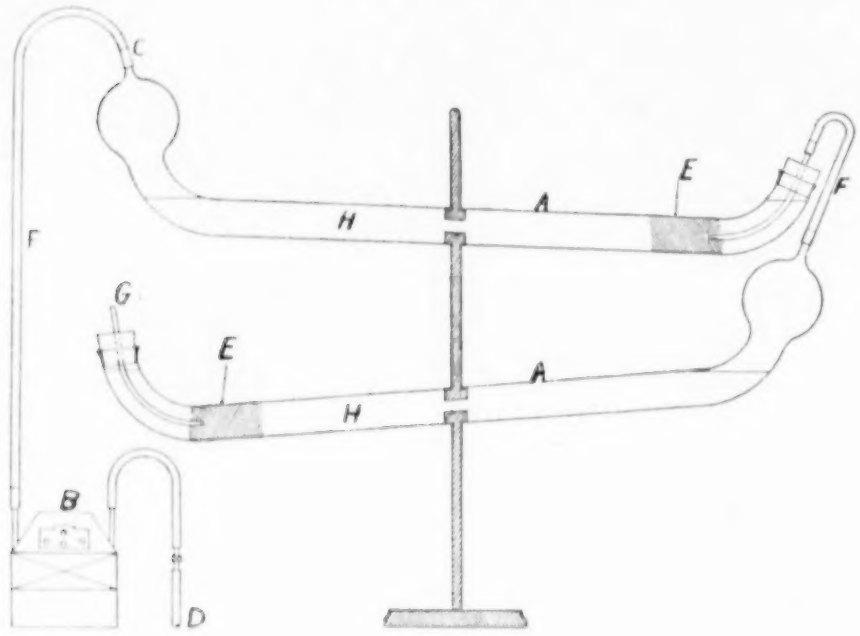

FIG. 1.—Arrangement of apparatus in Pettenkoffer tube method of determining aniline vapors in air.

A. Pettenkoffer tube. B. Gas meter. C. In preliminary tests, point of attachment to aspiration apparatus; in application of method, point of attachment to gas meter. D. Point of attachment to vacuum. E. Glass wool. F. Rubber tubing. G. In preliminary tests, point of attachment to flask of aniline; in application of method, point of entrance of sample. H. Ten per cent. solution hydrochloric acid.

by the hydrochloric acid. The sample was then poured off into 250-c.c., clean, glass-stoppered bottles and titrated.

2. *Modification of the Pettenkoffer Tube Method Used for Determining Per Cent. of Carbon Dioxide in Air.*—Two Pettenkoffer tubes were connected by means of rubber tubing to each other and then connected with a gas meter which was connected with a vacuum. The tubes were filled with about 100 c.c. of an approximately 10 per cent. solution of hydrochloric acid, glass wool being placed at the proximal end of each tube. The air to be tested was then allowed to bubble through the tubes as slowly as possible, and the number of cubic feet of air drawn through the tubes recorded by the gas meter. (See Fig. 1.) The samples were placed in 100-c.c. bottles and the tubes washed with hydrochloric acid solution. The samples and washings were titrated.

An explanatory note should be given to the tabulated results of the tests (Table 1). Samples 1 and 2 were taken at the floor level, whereas samples 3, 4 and 5 were taken at the level of the worker's mouth. Sample 2 shows a higher percentage of aniline than sample 1, but it took longer to empty the reducer, during the dropping of which sample 2 was taken, than it did to empty the reducer during the dropping of which sample 1 was taken. In dropping the second reducer, the reducer became clogged with iron oxide and, in opening up, the liquid slopped out and collected in a tray, permitting more aniline fumes to escape than is customary. This accounts for the high aniline content of the air. Sample 2 by the carboy method shows a lower percentage of aniline than the same by the Pettenkoffer method; this is due to the fact that the carboy sample was taken before the aniline began to slop over the sides.

Significance of the Preceding Tests

As regards the tests for free aniline in the air, the following points should be emphasized:

(a) An appreciable amount of aniline was obtained from the air by both the carboy and Pettenkoffer methods. Moreover, the results of these two methods made on the same sample checked up very well. The value of the Pettenkoffer tube over the carboy is that it is easier to handle and hence more practical. Also larger samples can be obtained, for the Pettenkoffer apparatus can be set up and allowed to run continuously for as long a time as desired.

(b) Considering that according to Kobert 0.0004 gm.–0.0006 gm. of aniline per liter in the air can be breathed for one-half to one hour without severe symptoms, and 0.0001 gm.–0.00025 gm. per liter is the

smallest amount that after continued exposure will produce slight symptoms (5), we find that the results of all titrations show, with the exception of sample 3, that the workers in the plant studied were working under more or less toxic conditions. It must be borne in mind, however, that the workers are constantly moving about and not breathing continuously the air containing such a high percentage of aniline.

(c) The results of tests show that at the floor level the amount of aniline is decidedly greater than at the respiration level. This is due to the fact that aniline is much heavier than air and hence stays near the floor.

TABLE 1. — TABULATED SUMMARY OF RESULTS OBTAINED FROM TESTS MADE IN ANILINE AND INDIGO BUILDINGS

No. of Sample	Phase of Process Involved	Duration of Process in Minutes	Method Used in Collecting Samples	Method of Titrating	Amount of Aniline in Grams in Sample	Amount of Air Sample Collected in Liters	Amount of Aniline in Grams in 1 Liter of Air	Amount of Aniline in Grams Worker Inhales during Process	Per Cent. of Aniline in Acid Sample Collected
1	dropping reducer	20	Pettenkoffer	I	0.035403	34.809	0.00101	0.1722	0.009
1	dropping reducer	20	carboy	I	0.016527	13.930	0.00118	0.2004	0.0033
2	dropping reducer	40	Pettenkoffer	I	0.0653275	18.753	0.0034	1.176	0.0041
2	dropping reducer	40	carboy	I	0.044859	18.425	0.00243	0.8257	0.0135
3	dropping reducer	20	Pettenkoffer	I	0.02118	40.469	0.0005	0.08888	0.0052
4	emptying of phenylglycine in indigo house	20	Pettenkoffer	II	0.04236	58.581	0.0007	0.1224	0.1126
5	emptying of phenylglycine in indigo house	30	Pettenkoffer	II	0.04944	43.582	0.0017	0.2889	0.1106

Conclusion

The results of tests made for determining quantitatively the presence of aniline vapors in the air have given rise to the following conclusions:

1. The sodium nitrite test as described under methods I and II of the titrations is an accurate quantitative method for analyzing the presence of aniline in weak solutions.

2. The carboy method can be used for determining quantitatively the presence of aniline in the air, but the method is an awkward one owing to the fact that the carboy must be large enough to give a sufficient volume of the sample (at least 25,000 c.c. of air).

3. The Pettenkoffer method, as previously described, is the best method for determining quantitatively the presence of aniline vapors in the air. It is valuable because (a) it can be run over a longer period of time and hence a larger sample can be obtained; (b) the apparatus is portable for it can be taken apart and carried in a small bag; (c) it is efficient since slow absorption can be obtained by means of the long tubes and the addition of glass wool. Additional surface can be obtained by introducing glass beads. The greater the resistance the more complete will be the absorption of the aniline vapors.

4. In collecting a sample of aniline from the air sufficient should be collected to make at least two titrations on each sample. The longer the experiment is run the larger will be the amount of aniline present and the more accurate will be the results.

5. The results show that aniline is present in the air surrounding buildings where aniline and aniline products are made, its presence being greater near the floor than at the respiration level.

The above results point toward the use of Pettenkoffer tubes as a feasible method for determining quantitatively the presence of aniline vapors in the air.

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